Findings on future issues related to water production and use

The most significant constraints relative to production and use for water resources in the State are discussed in DWR Bulletin 160-98 and the Critical Water Shortage Contingency Plan (2000) and summarized below.

Population growth

With a 2002 population level of 34 million people, forecasts for 2020 estimate a 33 percent increase to 46 million people. Population growth drives the increase in urban water use from the current 8.8 maf to 12 maf by 2020. This represents a 36 percent increase over 1995 levels. As urbanization shifts to inland areas, high per capita water use results from warmer and drier climate and more landscaping water uses (Department of Water Resources, 1998).

The implementation of the Urban MOU for conservation measures should reduce urban demand, although urban conservation measures are already built in to the projected 2020 and significant increases are still predicated. While total demand for urban uses of water are expected to significantly increase, per capita rates are expected to decrease by eight to 16 percent by 2020. This decrease would be primarily due to the MOU conservation requirements (Department of Water Resources, 1998).

Environmental use requirements for water

In California, ecological uses account for the largest portion of water consumption. Over 36.9 maf are allocated for ecological uses. As population expands, the concern for preserving and restoring California's ecosystems will increase, creating even greater demand for ecological uses. Concerns related to ecological use include timing, flow quantities, and temperature altering aquatic biodiversity. Environmental uses of water include a wide variety of species habitat, recreational, and pollution control purposes. Additionally, environmental allocations for the San Francisco Bay and Sacramento/San Joaquin River Delta may create increases of alternate uses.

Aquatic habitat. Photo courtesy of Department of Water Resources.

One example of dedication of water for environmental uses is the CALFED's Ecosystem Restoration Program emphasis on recovering fish species that have Endangered Species Act listings or have had an ESA biological opinion. These types of management programs not only affect the water supply availability for urban or agriculture uses, but will also have a costly affect resulting from increased dedications (Critical Water Shortage Contingency Plan, 2000).

Regulatory controls for ecological uses

Regulatory controls for water uses are expected to increase. Controls such as CALFED's Bay Delta operations, Federal Energy Regulation Commission re-licensing of power facilities, Endangered Species Act, Colorado River usage concerns, and new California ballot initiatives will all lead to increased demands for environmental water uses. Ecological uses of water also represent a mandatory allocation of water, even in drought years. This means that ecological uses are met first, often at the expense of other urban or agricultural uses.

The changes in regulation to protect in-stream flow levels for fish are numerous. A summary of these regulation changes can be found in Chapter 2 of Critical Water Shortage Contingency Plan. These changes have a potentially significant effect on surface water management.

Klamath Basin's battle over water:"Fish get water; farmers get sympathy," yelled the oversized headline in the Klamath Falls newspaper in early April of 2001. The U.S. Bureau of Reclamation had just decided that no irrigation water would be diverted for the year from Upper Klamath Lake into the Klamath Reclamation Project's irrigation system, used by about 1,400 farm families on the California-Oregon border (Kepple, 2001). What had led to this unprecedented decision was a combination of extreme drought, changing federal mandates over the most important use of water, and uncertainty over the best strategy to protect native aquatic species in a highly regulated water system within a complex ecosystem. If in doubt, the prevailing argument said, err on the side of caution and in favor of the three endangered species of fish by giving all of the scarce water to them rather than to the farmers.

With precipitation at one-third of normal and everyone demanding their fair share of the dwindling water supply, the one-hundred-year-old federal Reclamation Act collided with the 30-year-old federal Endangered Species Act (ESA). The Bureau's role as wholesale water supplier for 170,000 acres of pasture and cropland in the upper Klamath Basin evolved out of the nation's desire to promote settlement through irrigated farming in the then-underpopulated, arid West.

In contrast, the U.S. Fish and Wildlife Service's role as protector of the endangered species of sucker in Upper Klamath Lake developed out of the country's more recent sense that various species of fish and wildlife may be going extinct due to rapid economic growth and development. A similar role belongs to the National Marine Fisheries Service in its protection of the threatened coho salmon of the Klamath River, below the lake and several hydropower dams. With tribal claims to upstream and downstream water getting louder, conflict over water was brewing into a huge storm. Glossed over in this growing power struggle was the additional water need of the Klamath Basin National Wildlife Refuges' wetlands.

After years of irrigation use prevailing, legal arguments based on the ESA's protections for endangered species ended up superseding the Reclamation Act's obligations to deliver water in the upper Klamath. Biologists from the two Services were convinced, based on their interpretation of the available scientific evidence, that both a higher lake level and increased river flows were necessary to ensure the survival of the three fish species, leaving no available water for irrigation in the record-setting drought of 2001.

Angry and well-publicized protests by Klamath farmers with dry, cropless fields and impacted communities triggered a request by Secretary of Interior Gale Norton for a review of the science by the independent National Academy of Sciences (NAS). The Academy's interim report did not find scientific support for the proposed higher lake levels or for the minimum river flows to help maintain or recovery the species (NAS 2002). On the other hand, it also did not support the extreme reduction of flows originally proposed by the Bureau. A more comprehensive analysis with recommended long-term strategies is expected in 2003 from the NAS. Focusing on the bigger picture, observers predict "the new world is coming" of a more sustainable balance between regulatory controls helping ecological uses and plumbing systems helping family farms in the Klamath Basin (Wilson 2001).

Agricultural uses

The use of water for agricultural purposes is projected to decline by 2.3 maf, a 4 percent decrease by 2020. This is due in part to the expected decrease in the agricultural land base primarily due to urbanization. Irrigated crop acreage is also expected to decline by 325,000 acres from the 1995 level of 9.5 million acres to 9.2 million acres by 2020. However, trends to more valuable permanent crop plantings (e.g., vineyards and orchards) may result in higher water use levels during drought periods. These permanent plantings must be irrigated every year in contrast to the practice of not irrigating lower value lands with annual crops during droughts. This could be particularly critical in the San Joaquin Valley and in areas of Amador and San Luis Obispo counties. Where agriculture areas have increased permanent plantings, there are limited options for fallowing land (Critical Water Shortage Contingency Plan, 2000).

Another factor relating to the projected decrease in agricultural use of applied water is related to increased water use efficiency. The furthering of agricultural conservation Efficient Water Management Plans (EWMPs) should continue the trend of decreasing demand for agricultural uses. Fundamental objectives of the EWMPs are to reduce evapotranspiration, surface evaporation, and irrcoverable deep subsoil losses. Such EWMP practices as recycling, ditching, irrigation efficiency, and voluntary transfers of excess water will result in reduced demands of over one maf per year.

Water quality requirements

Water quality demand and supply can drive allocations of water for urban, agricultural, and environmental uses. As urban and environmental uses demand high quality water, water managers must respond to find adequate sources and treatment methods. Currently, there is substantial statewide emphasis on water quality issues that focus on factors such as eutrophication, mineralization, temperature, turbidity, heavy metals, pathogens/bacteria, urban pollutants (e.g., grease, oil, disinfectants, and/or organic debris), agricultural pollutants (fertilizers), nitrates, and atmospheric depositions. Water quality efforts include conservation of urban runoff, wastewater sewage controls, agricultural subsurface recycling and desalting, and toxicity reduction.

Land use planning

Patterns of future development and resulting water use are dictated by city and county land use planning decisions. Development in drier areas, urbanization of agricultural lands, open space preservation, habitat creation, and wetlands preservation policies are examples of land use-related decisions that have water use implications.

Location of development in drier areas expected to experience high growth rates include some San Joaquin Valley counties and or in Southern California. This population shift to warmer, drier inland areas where urban outdoor water use is higher affects future statewide water demands.

The location of urban development also affects agricultural water use. For example, subdivisions constructed on non-irrigated grazing lands do not directly displace agricultural water use, but subdivisions constructed on irrigated farmland result in direct conversion of water use from agricultural to urban.

Local open space preservation goals can affect the extent of land use conversion and water use. For example, some land use planning agencies in urban areas have set aside ridge top areas as lands to be managed for recreation or open space to preserve view sheds. If the areas set aside are non-irrigated grazing lands, water use impacts are minimal. However, policies to preserve and enhance wetlands can entail creating new wetlands or providing increased water supplies to existing wetlands, thus increasing environmental water use, often by conversion of agricultural water supplies. Programs creating new wildlife habitat areas would entail conversion of agricultural lands and water supplies to environmental uses (Department of Water Resources, 1998).

Climate and precipitation levels

With precipitation the source of all water supplies, global changes affecting California climate have a dual affect on water balances. First, changes that increase or decrease precipitation will determine supply levels. Second, changes toward drier and hotter conditions will affect consumption.

Climate change and water runoff in California

California's climate is noted for its natural rainfall variability both geographically, from the extreme highs of the Smith River basin to the extreme lows of the Mojave Desert, and seasonally, from severe floods to critical droughts. Climate changes brought on by global warming—from whatever cause—are predicted to increase this variability and therefore the uncertainties of the State's water supplies (McClurg, 1998). Debate has shifted in recent years away from whether climate change is occurring to what can be done about it (Gleick, 2000). The potential impacts on California's water resources remain a focus of new studies and discussion.

With the observed and predicted warmer temperatures, scientists expect an increase in overall precipitation globally. Snowfall, however, is predicted to decrease. Even small changes in temperature could have effects. A shift in seasonal precipitation (from less snow in the winter to more rain) could lead to an increased intensity of storms and new flood threats. With less snowmelt, spring runoff would be reduced causing decreased summertime stream flow.

With less snowmelt, spring runoff patterns will be lowered and decreased summertime stream flow will likely result.

While regional differences in the State are challenging to predict, hydrologic models measure a range of potential climatological future temperature shifts and precipitation ratios. These models reveal that in all cases, a larger proportion of the stream flow volume will occur earlier in the year (Miller et al, 2001) and there will be a higher probability of high flow days overall. The amount and timing of the change in each hydrologic basin is dependent on local characteristics, especially the elevation of the freezing line. Despite innate uncertainties with the model projections, the future range of hydrologic response to climate change in California can be bracketed. With this qualified information, better decisions should be able to be made about water supply and flood control planning.

Assessing the consequences of climate change on yields and water use of major California crops is the focus of another recent study (Adams et al, 2002). Since the majority of the State's crops are irrigated, any changes in precipitation will likely have little direct impact on water use or crop yields. However, annual precipitation changes can affect the amount of runoff and water supply available for agriculture. In the cooler regions of the State (i.e., mountainous, coastal, and, to a lesser degree, the Sacramento Delta areas), warmer temperatures during the crop-growing season will be generally beneficial for crop productivity, but will have negative effects in the warmer regions of the San Joaquin and Desert areas. As long as water supplies remain adequate to produce these crops, climate change is not likely have serious adverse effects on the yields of most California crops.

The assumption of water supply adequacy is debatable in light of the predicted changes in runoff patterns. Juggling reservoir storage space for possible increased flooding in the winter with additional summer flow needs will be a challenge. The logical reaction would be to increase water storage to offset expected supply losses and increase flexibility. However, State officials appear reluctant to expend large capital outlays to expand water storage facilities because of the uncertainties of possible future climatic change (McClurg, 1998). Climate change scenarios are not built into the most recent California Water Plan (Department of Water Resources, 1998). The U.S. Global Change Research Program's Water Sector Assessment Report notes that "sole reliance on traditional management responses is a mistake" and encourages pro-active management and planning steps for water resources (Gleick, 2000). Some of the recommended alternative forms of new supply are already being applied in California such as water recycling, water marketing and transfers, desalination, and conjunctive use of groundwater. In all scenarios, the trend is toward higher water costs.

Juggling reservoir storage space for possible increased flooding in the winter with additional summer flow needs will be a challenge.

Groundwater overdraft shortages

Although the amount of water stored in California's groundwater basins is far greater than in surface water reservoirs, only a fraction can be economically and practically used (Critical Water Shortage Contingency Plan, 2000). In normal years, about 30 percent of California's urban and agricultural water is supplied by ground water. Ground water sources are particularly important to rural users in forest and rangeland areas. Rural users often are not on municipal water systems and are dependent on small water systems and individual wells. As population growth and interest in transferring ground water resources for marketing opportunities increases, pressure on rural groundwater supplies are likely.

Overdrafts are expected to continue at a rate of about 1.5 million acre-feet per year. The primary factors affecting overdraft are drought, development, reduced CVP supplies, and Delta extraction restrictions from the San Joaquin and Tulare Lake regions (Department of Water Resources, 1998). In 2000, the Governor's Advisory Drought Planning Panel's water shortage plan identified the Sierra, Klamath/North Coast and Central Coast bioregions as particularly susceptible due to their hydrogeology. Additionally, there are virtually no existing programs to assist such water users and rural counties often lack resources to provide assistance (Critical Water Shortage Contingency Plan, 2000).

Water management opportunities

Water marketing

Water marketing is the process of buying, leasing, or selling water or water rights to gain access to a water supply (Newcom, 2001). California has no formal water market. However, CALFED and DWR have begun to discuss the topic. CALFED has developed its On-Tap to provide a database of past (and eventually current) water transfers. The website includes a detailed description of the permitting or approval steps needed for a specific transfer to occur.

DWR provided an Emergency Drought Water Bank in 1991, 1992, and 1994. The 1991 bank derived water from 3 sources, some from surface reservoir storage where the owners could spare some water, some from ground water pumping, and some from fallowing. About half the 1991 water bank purchases came from fallowing land. The smaller 1992 water bank paid $50 per acre-foot and sold at $75 plus conveyance costs. While water purchases for sold to primarily urban users, purchases were made to help address fish and wildlife needs. The California Legislature approved funding to also purchase 28,000 acre-feet of water for in-stream and wildlife habitat uses.

Purchasing water for fishery values in the San Francisco Bay Delta estuary is a primary purpose of the Environmental Water Account (EWA), a program supported by both DWR and the U.S. Bureau of Reclamation. In 2001, EWA purchased about 385,000 acre-feet paying from $75 to $300 per acre-foot to willing sellers. Similarly, the Bureau of Reclamation Water Acquisition Program spends approximately $10 million annually to obtain around 100,000 acre-feet of water necessary for full wetland habitat development of certain state and federal wildlife refuges in California. Price varies according to water availability but ranges from $60 to $70 per acre-foot in good water years up to $100 to $125 an acre-foot in dry years.

In contrast, developing new water supplies can be much more expensive. The construction cost of traditional surface storage is $325 to $425 per acre-foot. However, allowing land to fallow or using underground aquifer capacity for storage is estimated to cost $175 per acre-foot (Howitt, 2000). Advocates of an expanded water market in California hope that water pricing will better reflect the true cost of water. This would provide an alternative supply of water through the voluntary reallocation of existing supplies (Howitt, 2000).

The construction cost of traditional surface storage is $325 to $425 per acre-foot, while allowing land to fallow or using underground aquifer capacity for storage is estimated to cost $175 an acre-foot where conveyance facilities exist.

In a water market system, it is argued that individual incentives and financing for technical change can be provided to reallocate the water more efficiently. Treating water only as a commodity or economic good, however, has its critics (Gleick et al, 2002). Since a "new economy of water" also implies increased privatization over the management, operation, and even the ownership of public water systems, concern is raised about the associated responsibilities of private entities over water that is also a social good. Achieving a balance of the economic benefits of the private sector with the social safeguards of public oversight will be another policy challenge for California.

Market–based pricing mechanisms may lead to better allocation results. Past studies have shown price elasticity effects from water pricing changes. Elasticity results for both urban and agricultural water range from -0.1 to -0.4. This means that when there is a 10 percent increase in price there is a 1 to 4 percent reduction in water use. The greatest elastically response was found in the South Coast urban regions during summer drought conditions.

Water yield improvement through vegetation management

Historically, forests were commonly believed to be able to prevent floods (Leopold, 1994). However, hydrologic research indicates that extreme flood events occur when the drainage basin is completely saturated and can no longer store additional water irrespective of the vegetation cover. At that point, all rainfall and snowmelt become runoff. Vegetation has a mixed effect on surface runoff under these conditions. The major benefit from vegetation is a reduction in erosion and the slowing of sediment movement.

However, vegetation removal can have some short–term effects on stream flow. A review of the research on the effects of forest practices on water quantity reveals several observations (Adams and Ringer, 1994). When only a small portion of a watershed is harvested, no obvious flow change is observed. When more than 15 to 20 percent of the forest canopy is removed, stream flow tends to increase. These increases occur mainly during the rain or snowmelt season, so downstream reservoir or other storage is needed to benefit water supply. The observed increase becomes smaller with time as canopy regrowth increases evapotranspiration and water is lost the atmosphere.

If all of the riparian vegetation is removed, summer stream flows may increase for a short time. In coastal areas where fog drip may contribute significant moisture, logging can decrease stream flow for a short period until re-growth resumes the fog drip process. Some of the moisture in the fog and clouds will eventually be dropped farther inland. In summary, research findings do not support the concept that "trees act like sponges and then slowly release water to streams." Roots soak up much moisture but then the trees lose the water through transpiration. Runoff represents the amount of rain or snowmelt that is not absorbed by trees or other plants.

Water yield improvement can be a direct purpose and benefit of vegetation management on the watershed scale, but not necessarily on larger scales (Ponce, 1983). In a study of the Sierra Nevada mountains, researchers forecast an increase in water production of only about one percent under intensive forest watershed management on national forest land when conducted to meet other environmental constraints (Ponce, 1983). They concluded that delaying stream flow—mainly by creating small shaded forest openings to reduce snowmelt rates—may be the greatest contribution that vegetation management could make to meeting future water demands, given the state of reservoir storage and water use in California.

A more recent evaluation was done of possible changes in water yield and peak flows due to the long–term effects (1940 to 1989) of watershed conversion to a logged ecosystem. This evaluation used the South Fork Tule River in the southern Sierra Nevada as a case study (Marvin, 1996). The author's analysis did show an increase in peak flows tracked with time and cumulative logging and road construction, which were proxies for forest harvests. However, the analysis could not determine the size of the increase.

For western rangelands, a water yield practice is to replace existing vegetation with low–water using plants in order for more water to percolate through the soil to streams and ground water (Ponce, 1983). A potential to increase stream flows is only observed on rangeland sites with annual precipitation exceeding 18 inches (450 mm). Treatment response varies with vegetation type. The largest increases are possible in chaparral with little opportunity available in pinyon-juniper and sagebrush landscapes. If chaparral lands are successfully removed and the clearing is annually maintained, the long–term water yield increase is expected to average 2.4 inches per year over the area. However, a poor runoff response would result during a dry year and steep, unstable slopes may unravel when shrub root systems are removed. Any additional runoff to be gained would need reservoir storage to provide water use benefit.

Vegetation management in watersheds critical for municipal water supplies

Arguments are made on both sides of the issue of managing municipal water supply watersheds under an active or passive approach (U.S. Forest Service, 2000). Many Forest Service specialists argue that an active program of vegetation management designed to maintain the forest system and watershed processes within their natural range of variability can best sustain long-term supplies of high quality water. Users of urban water supplies often believe that watershed protection means no alteration other than the diversion of water. Vegetation will change over time and fire will ultimately play a role in the landscape, even in the most pristine watersheds.

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